

**ABSTRACT**

The invention provides a process, catalyst and apparatus for carrying out the water-gas shift reaction comprising employing a low-pyrophoricity water-gas shift reaction catalyst; wherein the low-pyrophoricity water-gas shift reaction catalyst comprises a solid high heat capacity particulate support impregnated with: (i) a reducible metal oxide and (ii) a catalytic agent.

UNITED STATES PATENT AND TRADEMARK OFFICE  
DOCUMENT CLASSIFICATION BARCODE SHEET

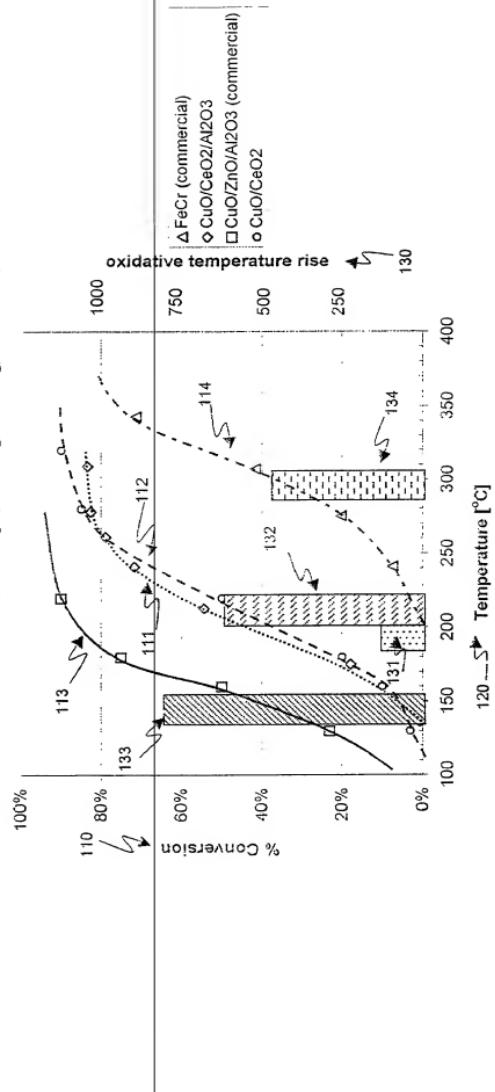


## Drawings

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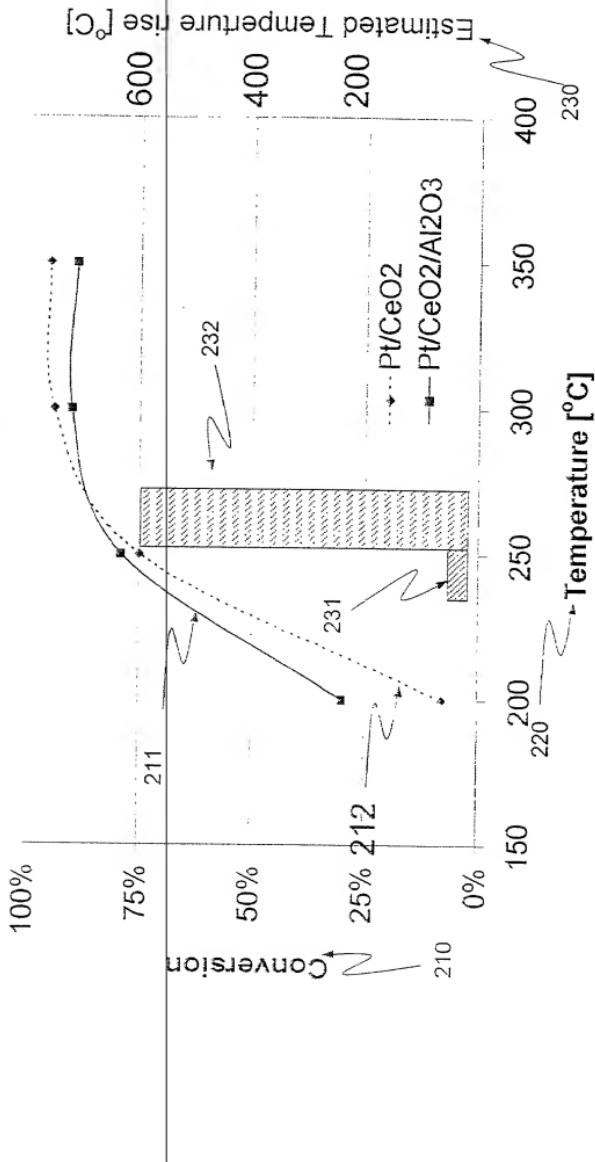
Figure 1

Activities (lines) and pyrophoricity (columns) of  
 $\text{FeCr}$ ,  $\text{CuO/ZnO/Al}_2\text{O}_3$ ,  $\text{CuO/CeO}_2$  and  $\text{CuO/CeO}_2/\text{Al}_2\text{O}_3$   
 2% CO, 10%  $\text{H}_2\text{O}$ , 20%  $\text{H}_2$ , 5%  $\text{CO}_2$ ; VHSV = 5,000  $\text{h}^{-1}$

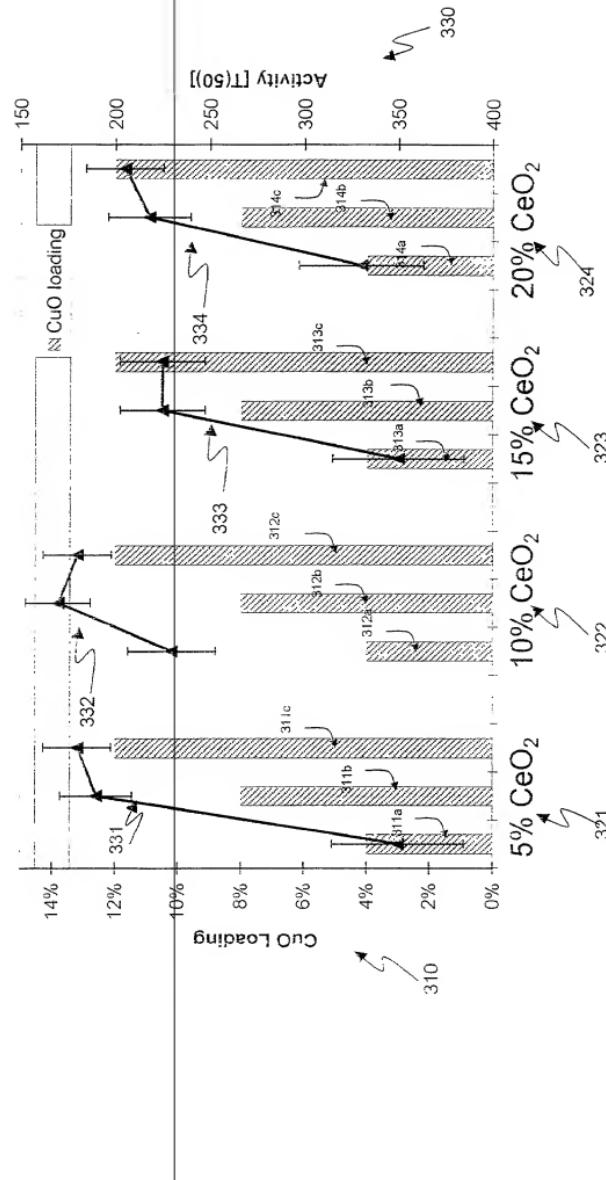


Comparison of activity (lines) and pyrophoricity (columns) of  
Pt/CeO<sub>2</sub> and Pt/CeO<sub>2</sub>/Al<sub>2</sub>O<sub>3</sub> catalysts

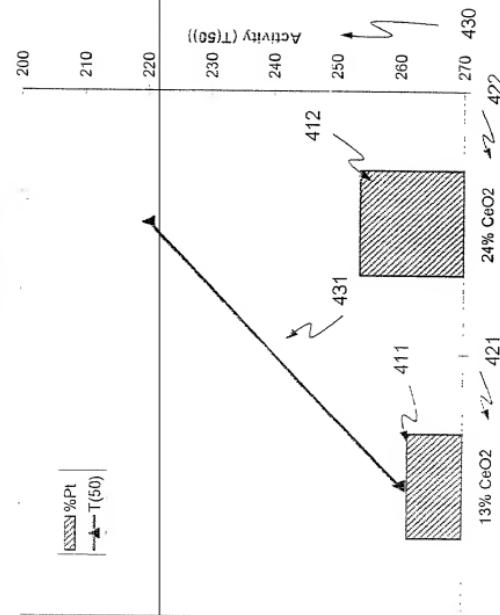
0.5% CO, 20% H<sub>2</sub>, +10% H<sub>2</sub>O, WHSV=24,000 h<sup>-1</sup>



Dependence of WGS activity on Ce- and Cu-loading  
 (18.846-29.38, samples WR-66, 75, exp. WR-57, 76, 78)  
 test conditions: 2% CO, 20%  $H_2$ , +10%  $H_2O$  balance  $N_2$  WHSV = 30,000  $h^{-1}$

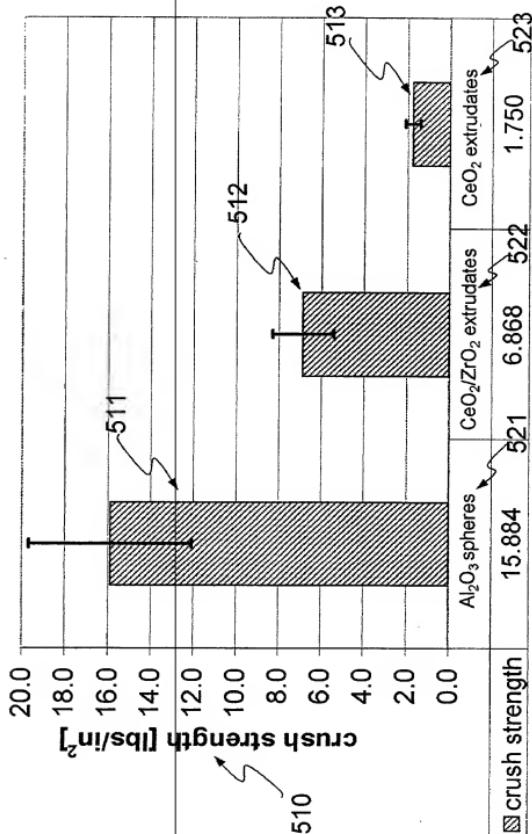


Effect of Ce and Pt loading on the activity of Pt/CeO<sub>2</sub>/Al<sub>2</sub>O<sub>3</sub> catalysts  
0.5% CO, 20% H<sub>2</sub>, +10% H<sub>2</sub>O, WHSV=24,000 h<sup>-1</sup>



# Crush strength of catalyst support particles

## Average and standard deviation of 20 samples



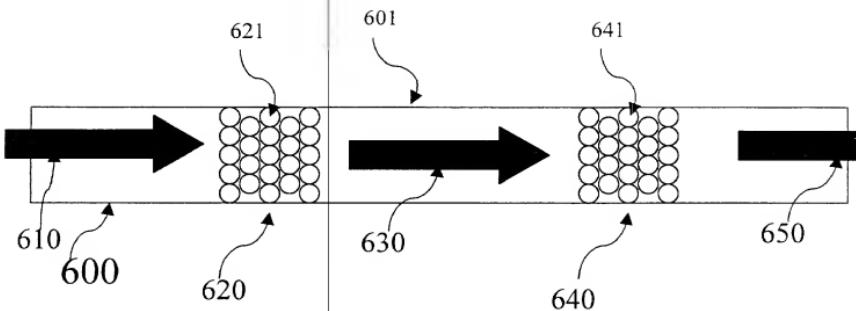


FIG. 6

Figure 7: Effect of  $\text{Cr}_2\text{O}_3$  Level on the Catalytic Activity of  $\text{CuO}/\text{Al}_2\text{O}_3$  WGS Reaction Catalysts

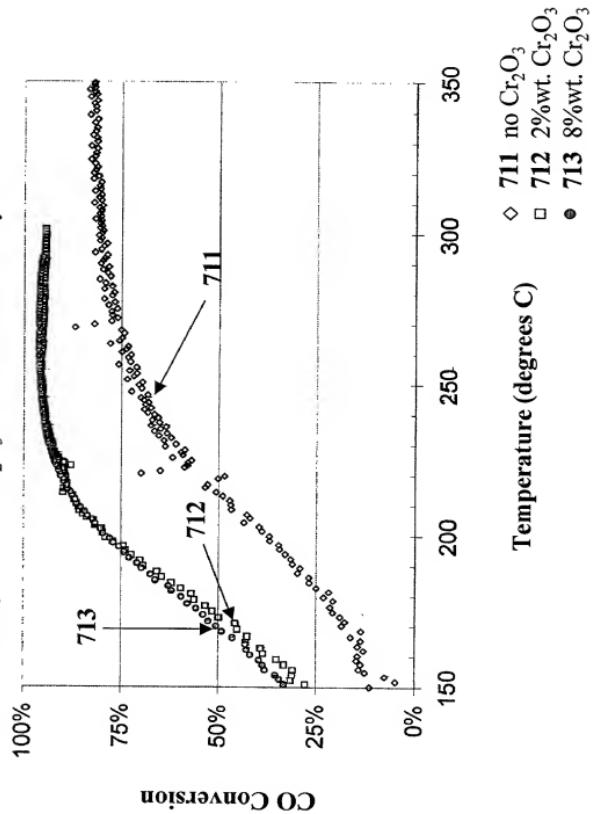
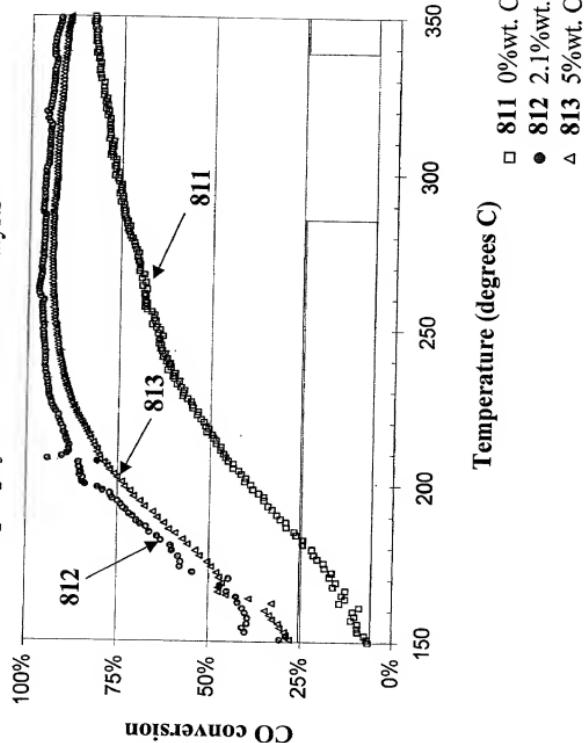


Figure 8: Effect of  $\text{Cr}_2\text{O}_3$  Level on the Catalytic Activity of  $\text{CuO}/\text{CeO}_2/\text{Al}_2\text{O}_3$  WGS Reaction Catalysts



**Figure 9:** Effect of the Sequence of Synthetic Steps on the Catalytic Activity of  $\text{CuO}/\text{Cr}_2\text{O}_3/\text{CeO}_2/\text{Al}_2\text{O}_3$  WGS Reaction Catalysts

